NADA ŠTRUMBERGER, D.Sc.
NATALIJA MALETIĆ, B. Eng.
Fakultet prometnih znanosti
Zagreb, Vukelićeva 4
INES CVEČIĆ, B. Eng.

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OIL IN TRANSPORTATION – ADVERSE IMPACT ON THE SEA

ABSTRACT

In the cycle from production to consumption there is liquid cargo which is mostly transported by sea. Optimisation of tanker dimensions since the sixties has required construction and exploitation of ever bigger vessels and the tendency of stricter responsibilities: "objects of higher responsibility". Today, liquid cargo makes up almost half of all the cargo transported by sea. Transportation of such staggering amounts is very complex both from the aspect of general safety during navigation and in operations at the terminal, since such cargo represents harmful substances according to the SOLAS Convention regulations (rule VII/2). The awareness of the threat to the human environment, land, shores and sea, stimulates development and affirmation of ecology as science of very strict bans and requirements towards every activity which may be a potential source of wider pollution. The effects of oil on the sea regarding composition and properties may be chemical, physical and biological, disturbing as a rule the natural balance of the ecosystem at all levels. Special significance lies in the study of the influence that oil, its products and surface active substances (dispersers) have on the larvae and ova of sea organisms – the most sensitive phase of life cycle in the sea, which mostly live in pelagic environment.

KEY WORDS

oil, transportation, sea

1. INTRODUCTION

The continuous increase of energy demands and consumption in the modern world is accompanied by the increase in the amount of oil and its products transported by sea, thus increasing also the danger of sea pollution. Pollution can be defined as an undesired change of physical, chemical or biological properties of air, soil or water which can be harmful for humans and other organisms, living conditions, industrial production, and natural resources. Crude oil is a liquid mixture of organic compounds whose composition and characteristics vary depending on the fields and includes many different ingredients, the most significant being hydrocarbons – CH. Hydrogen and carbon are the prevailing elements that constitute up to 98% of oil, whereas other ingredients include CH products with sulphur, oxygen, nitrogen, vanadium and mineral salts.

Oil refining products are obtained from crude oil by processes of fraction distillation, catalytic and thermal cracking, reforming, etc. The first in the series are gases (methane, butane, cyclopropane and cyclobutane) and lower liquefied paraffins, that together with several aromatics (from benzene to naphthalene) show significant solubility in water. According to the ascending order of specific density follow: petrol, diesel fuel, lubricants, oil, asphalt and paraffin.[1]

Harm, i.e. toxicity of oil is measured in the concentration which kills half of the organisms in a tested specimen within 96 hours. If the tested organisms show unusual resistance to toxic agents or die all, then the specimen is regarded as non-representative.

2. CHEMICAL AND PHYSICAL EFFECTS OF OIL SPILLS IN THE SEA

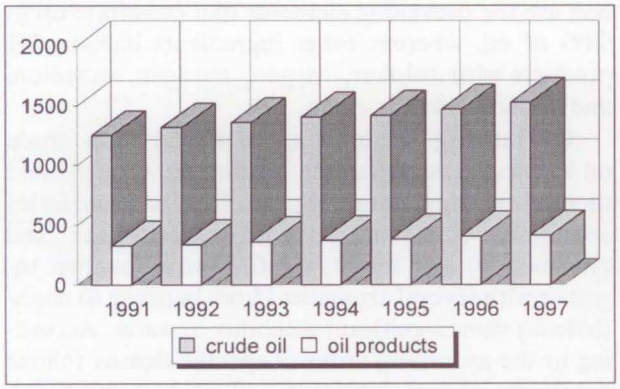
Crude oil floating on the surface of the sea as a layer that may be only few molecules thin, gets carried by the winds, waves and sea currents. Oil is exposed to evaporation and degradation, by dispersion of volatile ingredients into the atmosphere, by generation of emulsion in the sea water and by sticking to the stone substrates along the shores.

The change in oxygen consumption, influence on the degree of sea warming and the increase of the affinity towards pollutants, represent most striking chemical and physical consequences of oil spills. The change in consumption of oxygen marks the disturbance in the oxygen circulation cycle, including variability of concentration in the sea and sediments and its exchange between the sea and the atmosphere. Growth of temperature in spawning grounds, on sand surfaces or polluted rocks during low tide and sunny

Table 1 - Seaborne trade volume in tonnes
(mill. tonnes)

Year	Crude oil	Oil products
1991	1247	326
1992	1313	335
1993	1356	358
1994	1403	368
1995	1415	381
1996	1466	404
1997	1525	410

Source: Shipping Statistics and Market Review, ISL, Bremen, January/February 1999, p. 59.



Graph 1 - Seaborne trade volume in tonnes
(mill. tonnes)

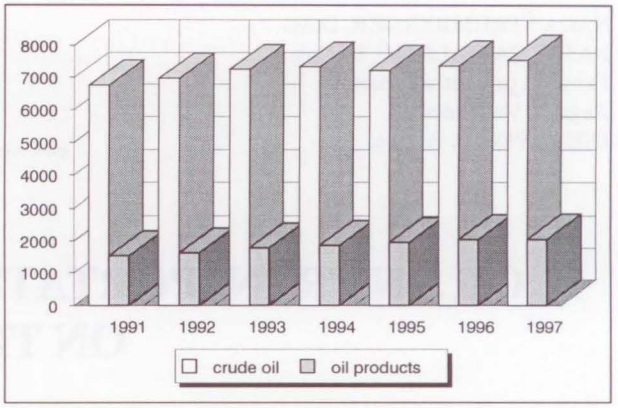
Source: Shipping Statistics and Market Review, ISL, Bremen, January/February 1999, p.59.

Table 2 - Seaborne trade in tonne-miles
(bill. tonne-miles)

Year	Crude oil	Oil products
1991	6757	1530
1992	6977	1620
1993	7251	1775
1994	7330	1860
1995	7224	1945
1996	7360	2045
1997	7550	2050

Source: Shipping Statistics and Market Review, ISL, Bremen, January/February 1999, p.59.

periods, all cross-sections of the sea can stimulate sudden breeding of certain species of organisms, e.g. algae that consume the existing amounts of oxygen and reduce insolation. The impossibility of development of some species, also as a consequence of temperature increase, disturbs the ecosystem balance in the sea and influences directly all members of the food chain.



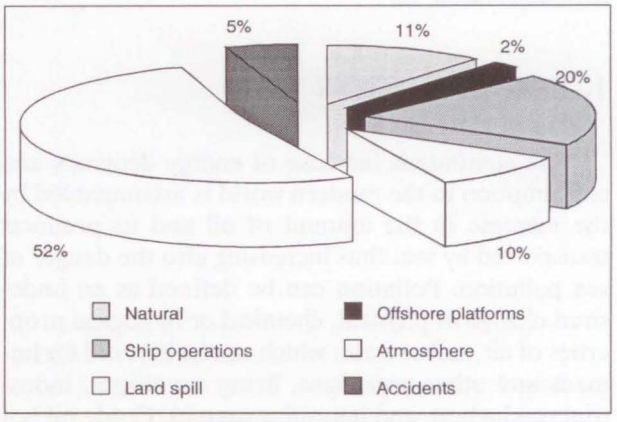
Graph 2 - Seaborne trade in tonne-miles
(bill. tonne-miles)

Source: Shipping Statistics and Market Review, ISL, Bremen, January/February 1999, p.59.

In the oil film on the sea surface polychlorinated hydrocarbons can concentrate as well as heavy metals brought into the sea from the sources located on land and on sea. Polychlorinated hydrocarbons (mostly pesticides) absorbed in great amounts can have mutation and cancerous properties and may cause genetic changes in the reproductive organs. Heavy metals, most often mercury and cadmium with the same properties can have even lethal effect. Their common characteristic is insolubility in oil and water, concentrating in fats and transfer into higher links of the food chain i.e. biomagnification.

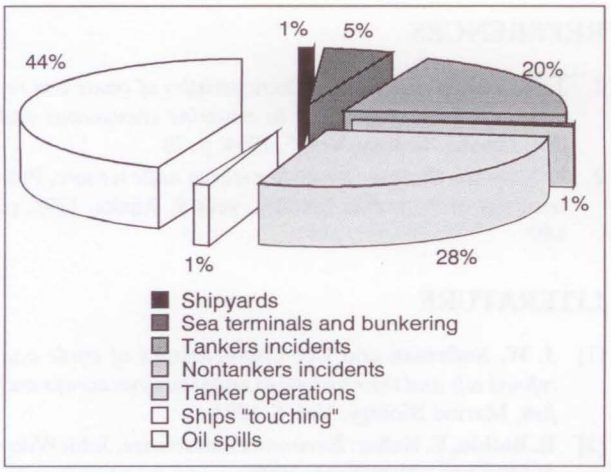
3. BIOLOGICAL EFFECTS OF OIL SPILLS IN THE SEA

Biological consequences of oil pollution can be toxically-latent, sublatent, carcinogenesis, immediate suffocation and asphyxation and physical and chemical changes in habitats.



Graph 3 - Sea pollution sources

Source: D. Botkin, E. Keller; Environmental science, John Wiley & Sons Inc., New York, 1995. p. 159.



Graph 4 - Sea-based pollution sources

Source: D. Botkin, E. Keller; Environmental science, John Wiley & Sons Inc., New York, 1995. p. 160.

Sea organisms that live at greater depths have higher resistance, and fewer oil ingredients reach them so that their survival is becoming easier. The amount of oil which sinks to the sea bottom depends on the waves and the condition and age of oil, as well as on the fact whether dispersers were used or not. Most organisms, if one manages to move them or they move by themselves into clear waters, have the possibility to survive (e.g. gastropods).[2]

Analysed data also show that the oil film on the sea surface causes less harm than oil emulsion. Influence of oil on pelagic organisms can vary from latent effects to significant changes in reproduction, nutrition and migration. Latent effects result mainly from the consequence of gill functioning or ingesting of greater amounts of toxic substances. High concentrations of oil, sufficient to cause significant mortality, are present near the sources of pollution. Oil is not absorbed through bodies of bigger sea organisms, since their outer skin has a jelly-like coating and they can dive in and swim away from the point of incident. The sticky slime of seaweeds and algae has similar properties. However, ova and larvae that usually float on the surface or live immediately below it are exposed to the harmful effect of oil with often high mortality rate. Crude oil spills into the sea are a great danger for the birds. Their ability to float and thermal insulation depend on the feathers whose microstructure and wax coating are water-proof, but absorb oil and then the birds cannot fly and they drown.

Organisms who live a part of their lives at the sea bottom, especially those in the tide zones, are very sensitive to oil pollution. High mortality in case of spills along coastal areas is experienced by organisms that are extremely sensitive to changes in the sea quality, such as sea urchins, molluscs and crabs. It has been proven that sea plants can survive substantial damage. Leaves covered with oil can never recover, but plants do not lose their reproductive properties, and survival depends on the season and on the food stocks at the time of the incident.

4. INFLUENCE OF ECOLOGICAL REQUIREMENTS IN TERMINAL DESIGN

At the beginning of exploitation and transportation of oil and oil products, tankers used to moor in harbours which handled all types of cargo. Over time, separate basins were constructed only for tankers, which shortened the stay of tankers at terminals and offered higher level of safety. In situations when it is technically difficult to adapt the existing on-shore terminals with the new requirements, the installation of off-shore terminals is pointed out as the only solution and a necessary investment. Since development of technology enabled installation of off-shore terminals at very inaccessible parts of sea bed, the location at a distance of a dozen or more miles reduces greatly the danger of catastrophe. Navigation along and between other ships to the dock is eliminated and tankers present less danger offshore than those anchored immediately at the harbour entrance. Actions of collecting oil on open sea are technologically simpler and faster compared to the coastal area which is biologically most productive and where oil sticks to the coast, docks, quays and other ships.

5. CONCLUSION

Liquid cargo is a necessary part of sea transport and as such poses continuous threat to sustaining the sea environment. Uncontrolled spills of cargo due to major incidents during navigation or the stay of a tanker at a terminal causes chemical, physical and biological changes in the quality of the sea. Some plants and animal organisms can adapt to these changes, but some show high mortality. Some organisms have oleophobic, and other oleophylic properties that may be fatal for them. The section of sea which they live in, nutrition method, chemical composition of the outer body surface, and the level of mobility, are the basic factors that influence the behaviour at the moment of contact with oil, and the probability of surviving without permanent damage. The installation or construction of terminals intended for liquid cargo handling, require that the possibility of reducing the influence of oil spill be considered very carefully, and the selection between an off-shore or on-shore terminal has to be brought in accordance with the requirements of sea sustainability.

SAŽETAK

NAFTA U PROMETU - UZROK NEŽELJENIH PROMJENA MORSKOG OKOLIŠA

U cirkulaciji od proizvodnje do potrošnje javlja se tekući teret koji se najvećim djelom transportira pomorskim putovima. Optimizacija dimenzija tankera od 60-tih godina nadalje, uvjetuje gradnju i eksploataciju sve većih plovnih jedinica i tendenciju postroženja odgovornosti: "objekti povećane odgovornosti". Danas tekući teret čini zamalo polovinu svih tereta pomorskog prometa. Prijevoz tako impozantne količine vrlo je složen s aspekta i opće sigurnosti pri navigaciji i operacijama na terminalu, pošto ti tereti spadaju u opasne tvari prema odredbama SOLAS Konvencije (pravilo VII/2). Spoznaja o ugroženosti ljudskog okoliša - kopna, obala i mora potiče razvoj i afirmaciju ekologije kao nauke veoma strogih zabrana i zahtjeva prema svakoj djelatnosti koja je potencijalni izvor šireg onečišćenja. Učinci nafte na morski okoliš s obzirom na sastav i svojstva mogu biti kemijski, fizikalni i biološki, pri čemu je u pravilu prirodna ravnoteža ekosustava poremećena i to na svim razinama. Od posebnog su značaja istraživanja djelovanja nafte, njenih derivata i površinski aktivnih tvari (dispergatora) na larvu i jajašca morskih organizama - najosjetljivije faze životnog ciklusa u moru koji najčešće žive pelagičnim načinom života.

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